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SERVICE MANUAL

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SERVICE MANUAL 2800/2810

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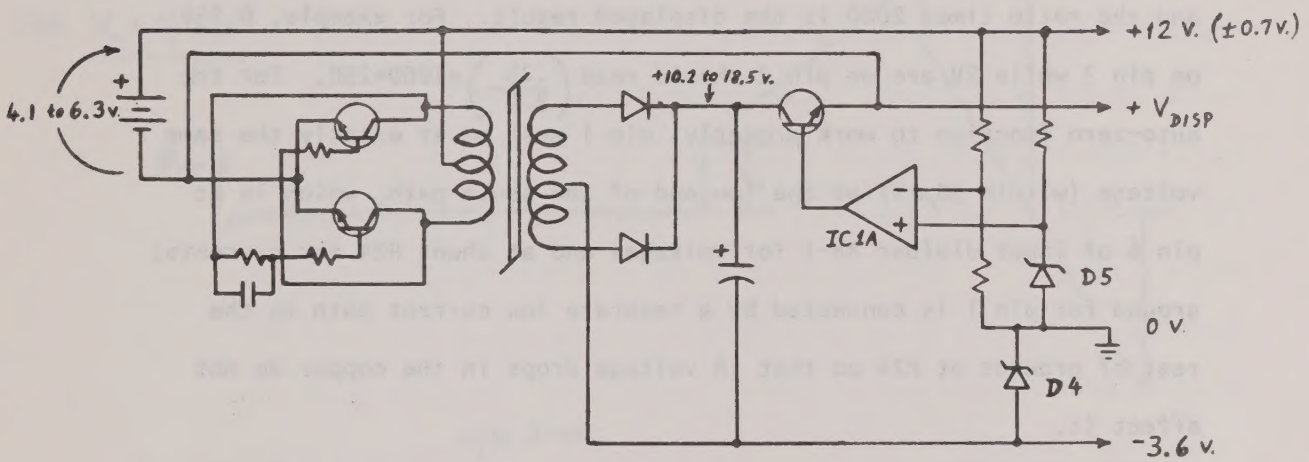
1. POWER SUPPLY (Fig.1)

The supply generates three D.C. voltages with respect to "ground" as shown. Note that there is a different symbol for "logic ground" which is a separate conductor carrying only the very small current (10nA max.) that pin 1 of IC2 requires. The L.E.D. displays and the digital circuitry that drives them are connected directly across the batteries, so the digits will grow dimmer as the batteries are discharged.

The battery voltage is chopped into a square wave oscillation (10V peak-peak, centered at +7V, for a 5V. batery)by the saturating-core round transformer and Q1 & Q2. The frequency increases with increasing battery voltage,ranging from approximately 10 to 15kHz; if a much lower frequency is observed, or if the battery current is exceptionally high (with 0.00DCV displayed and a 5V battery voltage, 120 to 140mA is about normal,200mA would be high),one of the two transistors may be bad (neither should be obviously warm; if one is,suspect that one). If both a 'scope and a power supply (in place of a battery) are to be used for checking this circuit,supply negative must be isolated from 'scope ground. The transformer secondary voltage is rectified,filtered,then controlled by Q3. IC1A compares the reference voltage (from high-stability D5) to a fraction (8/15) of the 12 volts and keeps the two equal by adjusting V Display. This 12V is the most tightly regulated of the supply voltages, and results in a constant current (0.50mA) to the special reference diode D5.

The "-3.6V" is more loosely regulated by zener D4 which operates near a relatively "soft" I/V curve knee. Thus the negative supply voltage shifts depending on the current through it which is the current through devices connected to ground, such as D5,IC5,and 1.274k (when switched to OHMS, IC5 becomes active so its supply current grows and "-3.6V" becomes about 0.4V more negative). Note that D4 can be blown by a customer accidentally using the ground (-) test lead to check battery (+12) voltage.

Fig. 1



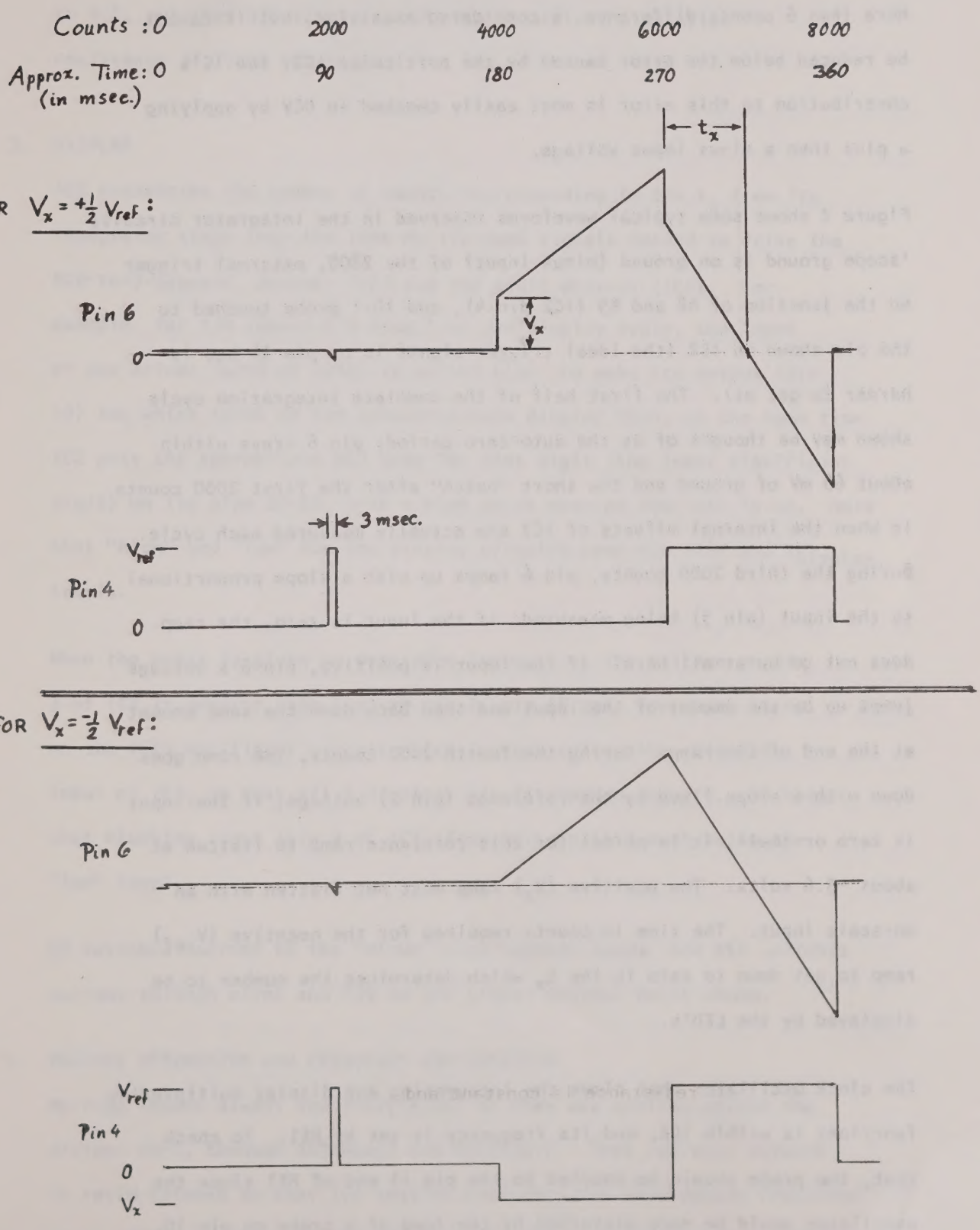
2. ANALOG-to-DIGITAL CONVERTER (Fig.2)

The heart of the meter is the dual-slope integrator and control circuits in IC2, the 24-pin chip. Input voltages are ultimately passed through R30 to pin 3 which leads to a very high impedance (approximately 1000MΩ) buffer then to the auto-zero circuit and the integrator. The voltage on pin 3 is compared to that on pin 2, both taken with respect to pin 1, and the ratio times 2000 is the displayed result. For example, 0.25V on pin 3 while 2V are on pin 2 should read $\left(\frac{.25}{2.0}\right)$x2000=250. For the auto-zero function to work properly, pin 1 must be at exactly the same voltage (within 50μV) as the low end of the sense path, which is at pin 6 of input divider RN-1 for voltages and at shunt R24 for currents; ground for pin 1 is connected by a separate low current path to the rest of grounds at R24 so that IR voltage drops in the copper do not affect it.

For all functions except DCA and the 3 low ohms ranges, full scale for the integrator is $\pm$2 volts; otherwise it is $\pm$0.2 volts. When in a 2 volt function, the higher V_{REF} causes IC1C to turn Q4 off (open circuited) so that R8 is effectly not there and the integration capacitor C9 is charged only through R9. When the reference is 0.2 volts, Q4 is on and R8 is in parallel with R9; the effect is that a smaller voltage (alternately V_X or V_{REF}) charges C9 through a smaller resistance so the resulting voltage ramp (at pin 6 of IC2) is about as steep as in a 2V function.

Note that when in an 0.2V function and hence Q4 is "on", there is still some drain to source resistance across Q4 as it is not perfect. As long as that resistance is constant and smaller than R8, it makes no difference; but, if the FET is weak (low I_{DSS} and high R_{ON}) its resistance may vary with V_X (seen through pin 4) with the result that a positive input and a negative input of the same magnitude (such as

Fig. 2


Counts : 0
2000
4000
6000
8000
Approx. Time: 0
(in msec.)
90
180
270
360
FOR $V_x = +\frac{1}{2} V_{ref}$:
t_x
Pin 6
V_x
0
3 msec.
V_{ref}
Pin 4
0
FOR $V_x = -\frac{1}{2} V_{ref}$:
Pin 6
V_{ref}
Pin 4
0
V_x

from running 1.9 mA through the meter in the 1mA DCA range, then reversing the leads) can produce considerably different readings. More than 6 counts difference is considered excessive, but it cannot be reduced below the error caused by the particular IC2; the IC's contribution to this error is most easily checked in DCV by applying a plus then a minus input voltage.

Figure 2 shows some typical waveforms observed in the integrator circuit; 'scope ground is on ground (minus input) of the 2800, external trigger on the junction of R8 and R9 (IC2 pin 4), and 10:1 probe touched to the pin shown on IC2 (the ideal trigger signal is on pin 14 but is harder to get at). The first half of the complete integration cycle shown may be thought of as the auto-zero period; pin 6 stays within about 60 mV of ground and the short "notch" after the first 2000 counts is when the internal offsets of IC2 are actually measured each cycle. During the third 2000 counts, pin 6 ramps up with a slope proportional to the input (pin 3) being measured; if the input is zero, the ramp does not go up at all here. If the input is positive, pin 6's voltage jumps up by the amount of the input and then back down the same amount at the end of the ramp. During the fourth 2000 counts, the ramp goes down with a slope fixed by the reference (pin 2) voltage; if the input is zero or small, it is normal for this reference ramp to flatten at about -3.6 volts. The positive (V_x) ramp must not flatten with an on-scale input. The time in counts required for the negative (V_{ref}) ramp to get down to zero is the t_x which determines the number to be displayed by the LED's.

The clock oscillator that times the integrating and display multiplexing functions is within IC2, and its frequency is set by R11. To check that, the probe should be touched to the pin 11 end of R11 since the oscillator would be more disturbed by the load of a probe on pin 10.

The reference voltage for IC2 pin 2 is divided down from "+8V" by resistors in RN-3 and pot R31. When it must be changed from 2 volts to 0.2, switches S1B (Front) and/or S2A(Rear) add a parallel resistance (1.773k) to ground.

3. DISPLAY

IC2 translates the number of counts corresponding to the t_x from its integrator stage into the time-multiplexed signals needed to drive the BCD-to-7-segment decoder (IC3) and the digit drivers (IC4). For example, for 1/4 (about 0.4 msec.) of the display cycle, the input of one driver (pin8 of IC4D) is pulled high to make its output (pin 10) low which turns on the common-cathode display DS-4; at the same time IC2 puts the appropriate BCD code for that digit (the least significant digit) on its pins 20-23, with a high there meaning that bit is on. Note that "high" and "low" for the display circuits mean the +12V and $V_{Display}$ levels.

When the meter is given an overrange input, i.e. the voltage on pin 3 of IC2 is greater than that on pin 2, pin 15 goes low which turns on the IC1D oscillator circuit which in turn pulses the blanking input of IC3, so that all 4 displays are flashed on and off. D6 keeps that blanking input (pin 4 of IC3) from being pulled much below the "low" level.

Q5 switches current to the "minus" sign segment anode and S1A switches current through wires and R39 to the proper decimal point anode.

4. VOLTAGE ATTENUATOR and FREQUENCY COMPENSATION

Voltage inputs always see 10MΩ (±10%) as they are applied across the divider RN-1, through S2B(Rear) and S2A(Rear). That resistor network is ratio-trimmed so that its smaller resistors are each decade fractions of its 9MΩ resistor. In the ACV function, DC-blocking capacitor C21

is put in series with the input. Compensation capacitor C20 is on the 100V range tap of the divider; if it were bad or missing, that would show up most on the 100V and 1000V ranges. On the other ranges, frequency response depends mainly on IC6 and its C16.

AC-to-DC CONVERTER

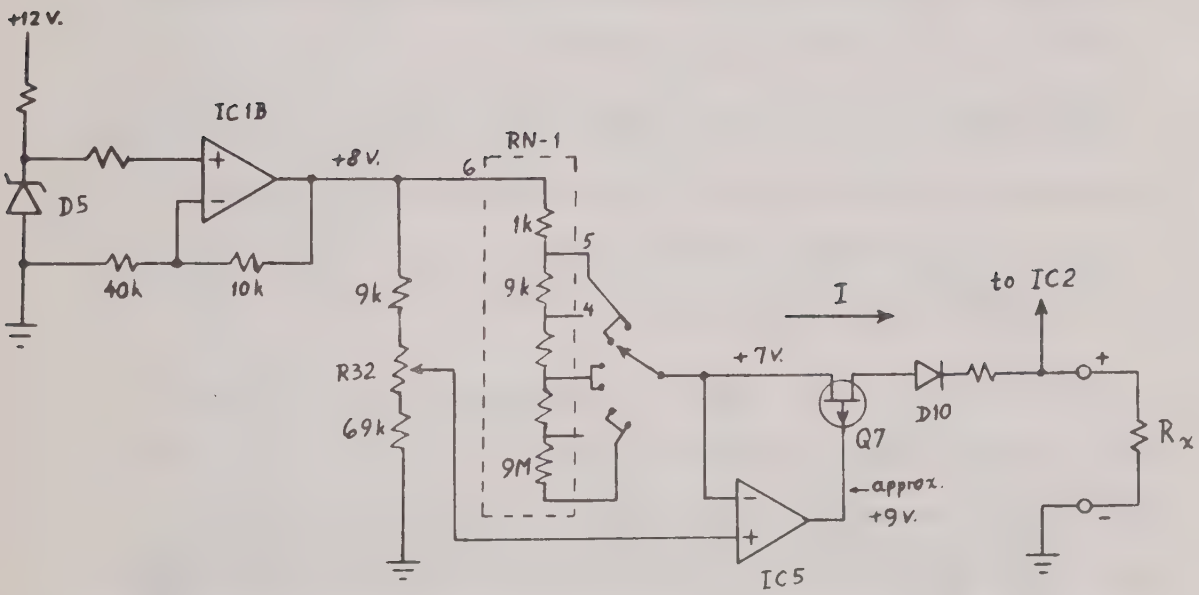
When set to ACV, signals are routed from the selected tap of RN-1 to the level-shifting buffer Q8. That JFET passes on AC voltages just as they arrive at its gate except that its output (called"D" on the PCB legend) is centered at about 3 volts DC instead of zero. That DC shift is needed to let IC6 drive the rectification circuit without clipping pin 6's negative peak for large input amplitudes. When scoping this circuit, R37 (i.e. the Drain of Q8) is often a good place to look first partly because this low-impedance point is not affected much by the load of the probe; the gate of Q8 is a sensitive high-impedance point protected by R38 and D9.

D7 and D8 rectify the signal, then the pot R33 and two ratio-trimmed resistors in RN-3 (414 and 3766 ohms) form a voltage divider which feeds back a fraction of the level-shifted voltage (centered about the DC voltage which is fed to R30) from D7 through coupling capacitor C17 to the inverting input of IC6. Only the AC component is fed back by C17, while R36 closes the DC loop for IC6. When set to ACA, the voltage gain of the stage is changed from 1 to 10 by shorting out the 3766 ohm resistor so that less of the output is fed back to the op amp's pin 2 (so output must swing ten times as much to keep inputs equal). Because the DC result on D7's cathode has so much AC on it, it is filtered by R34 and C12 before going through the other R-C filter (R30 and C7) to IC2.

6. OHMS CONVERTER (Fig.3)

For resistance measurements, a constant current is generated through

Fig. 3


+12 V.
IC1B
D5
40k
10k
+8 V.
RN-1
6
1k
5
9k
4
9k
R32
69k
9M
+7 V.
I
to IC2
D10
Q7
approx.
+9 V.
IC5
+
-
R_x

the unknown (R_x) and the resultant voltage is applied to IC2 through R30. In the 3 low ohms ranges, the current generated is the same as in the next higher (high ohms) range but V_{ref} is switched to 0.2V so that only 0.1999 volts across R_x produces a full-scale reading.

The current is generated by dropping 1.0 volt through the selected part of RN-1. IC5 controls Q7, which acts like a variable resistor, to keep its two inputs equal; since its input current is very small and the gate junction of Q7 is reverse-biased, virtually all the current from RN-1 goes through D10 and R_x to ground.

Note that in the top 2 ranges only 100nA (1V accross 10MΩ) is being passed through RN-1 and Q7 etc, so that a slight leakage (such as through a film of flux or a bad IC5 input) which did not show up on the lower ranges could badly affect these top two.

The ohms circuit protection depends basically on 1kV-rated D10, which blocks positive voltages accidentally applied to the meter input, and on R29. In normal use R29 has a resistance of about 2KΩ (±20%), but if a negative or AC voltage source is applied, then the current drawn through R29 heats it very fast and its resistance increases enormously (Positive Temperature Coefficient).

7. CURRENT MEASUREMENTS

In the 2 current functions, the input is switched through a 100, 10, 1, or 0.1 ohm shunt to ground and the voltage developed is sensed at the high end of R27. In DCA, that voltage goes directly to the A - to - D converter (IC2) in its 0.2V full scale mode. In ACA, the voltage goes first to Q8 and the AC circuit which now has a gain of 10 (instead of 1 as in ACV); its output goes to the A - to - D converter in its 2V full scale mode. If a clean DC current is passed through the meter when set to ACA, it should read zero

due to the coupling capacitors (C15 and C17) in the AC circuit. Protection diodes D11 and D12 limit the voltage that may be developed across meter input.

8. CALIBRATION

The sources used in calibration should have an accuracy of 0.1% or better, and the AC signal must be a clean sine wave. The procedure below must be followed in the order given, and is the same as the procedure in the customer manual.

a) Set unit to DCV 1V range.

b) Apply +1.9 volts to input and adjust R31 for a reading of 1.900.

c) Set unit to ACV.

d) Apply 1.9 volts RMS sine wave (any frequency between 50 and 400 Hz) and adjust R33 for a reading of 1.900.

e) Set unit to OHMS.

f) Connect 1.9KΩ ±0.1% to inputs and adjust R32 for a reading of 1.900.

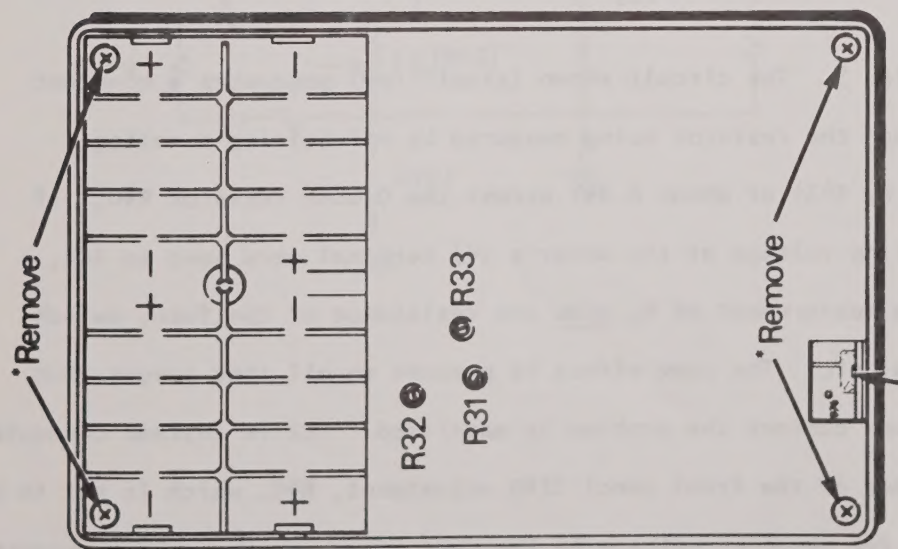

*Remove
R32
R31
R33
*Remove
* Unsolder (+) jack connection and remove 4 screws only when repairs are required. Do NOT disassemble for calibration ONLY.

Fig. 4. Location of internal adjustments.

9. MODEL 2810

There are 3 main differences between this model and the 2800: (a) a 100mV range is added for DCV and ACV, (b) there is now a choice between HIGH and LOW ohms functions on 1k through 1000k ohm ranges, (c) a 10-ohm range (20 ohms full scale) is added as a separate function.

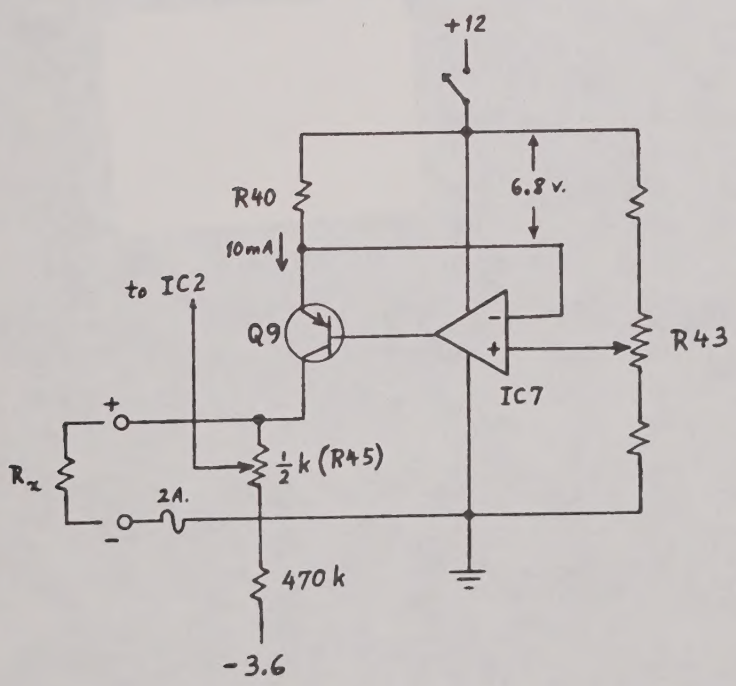
(a) The lowest voltage range is the same as the 1V range except that the reference voltage (to pin 2 of IC2) is switched to 0.2 instead of 2 volts.

(b) The ohms circuit is fundamentally the same as that shown in Fig.3, except that 2 taps in RN-1 previously not used in ohms are now used. On the 1k range, for example, switching from high ohms to low ohms means moving Q7 and the (-) input of IC5 from pin 5 to pin 4 (1k to 9k tap) on RN-1 and changing the reference voltage to 0.2V. Notice that both the 1k range in low ohms and the 10k range in high ohms use the same (9k) tap, so the current I through the meter jacks is the same (0.1mA), but the reference (and thus the voltage at full scale) is switched.

(c) See Fig. 5. The circuit shown (simplified) generates a constant 10mA through the resistor being measured by maintaining a voltage (adjusted by R43) of about 6.84V across the 0.684k resistor R40. If the resulting voltage at the meter's (+) terminal were sent to IC2, we'd see a measurement of R_X plus the resistance of the fuse, switch, test leads, etc. The same effect is present on all ohms ranges, but with so much current the problem is magnified. IC2 is instead connected to the wiper of the front panel ZERO adjustment, R45, which is set to be below the (+) terminal voltage by the same amount as the voltage across the fuse and test leads etc. (about 0.3 volt). The range switch should

be set to the 10V range to position the decimal point (the 10 Meg Ω range would do that too, but the reference voltage would be incorrectly set at 2V instead of 0.2). This whole circuit is disconnected in all other functions, to reduce battery current, and the ZERO pot has no effect in other functions (including the other 2 ohms functions).

Figure 5.



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